Snow Infiltration in Fresh Air Intakes
"What Can be Done"

M.J. SOLIGO AND G.D. SCHUYLER
Rowan Williams Davies & Irwin, Inc.
650 Woodlawn Road West
Guelph, Ontario N1K 1B8, Canada

ABSTRACT

This paper identifies the need to consider snow infiltration in fresh air intakes during the mechanical design phase. Methods of predicting the potential for snow infiltration and associated problems are given along with typical solutions.

BACKGROUND

The impact of snow infiltration on mechanical air intake systems is a well established problem faced by mechanical designers for cold weather regions. This problem is common in Canada and much of the northern and midwest United States.

As the mechanical details and emphasis on aesthetics of many new developments are becoming increasingly intricate, so too is the demand on mechanical designs. The most appreciated mechanical system is the one which is the least visible while maintaining appropriate efficiency. This, however, can lead to designs which increase rather than reduce the infiltration of snow.

The design of fresh air intakes for laboratories, hospitals and other such facilities is particularly demanding since the fresh air supply of these systems typically run at 100% of design, all winter long. The characteristics and operation of laboratory facilities require that the fresh air demand is met in order to maintain efficiency and avoid health and safety risks for the occupants. Commercial developments such as office complexes will generally not run at 100% of fresh air intake design during the winter months. This reduced intake of fresh air will generally reduce the rate of snow infiltration in the system. This fact does not exclude the need to evaluate the impact of snow infiltration for the mechanical systems of commercial developments; it generally results in the need for fewer design features to mitigate snow infiltration when compared to laboratory fresh air systems.

PROBLEMS ASSOCIATED WITH SNOW INFILTRATION

Entrainment of snow is the result of snowfall and of drifting/blowing snow. Snowfall alone can create numerous problems for an intake system. The same is true for drifting/blowing snow. For this reason, both aspects generally require individual and combined analysis to determine potential problems.

The problems associated with snow infiltration are generally serious in nature. Some of these problems are listed below with a brief description.

I) Clogged Screens/Collapsed Ducts - Snow which has infiltrated the fresh air system will generally accumulate on the screens and filters. Once these devices become saturated with snow, little, if any, air will pass through. If the system continues to try and draw fresh air, a low pressure will be created within the ducts thus creating the potential for the ducts to collapse.

II) Torn Filters/Internal Water Drainage - The accumulation of snow (and possibly ice) on the filters and screens can often create a tear in these devices thus allowing snow to flow freely into the internal ducting. The internal temperature will result in snow melt which often creates costly water damage to ceilings and walls.

III) Air Quality Problems - Snow accumulation on the filters and screens can result in a reduced supply of fresh air. In a laboratory, this can starve the fume hoods of air and create health and safety concerns for the occupants.

IV) High Maintenance - A fresh air supply system affected by snow infiltration typically requires continuous observation, a frequent change of filters and screens, monitoring of the amount of fresh air supplied, and effective protocol to handle any of the problems listed above. This requires an efficient maintenance program which can prove quite costly.

V) Difficult to Retrofit - In cases where a fresh air system has been constructed and snow infiltration proves to create significant problems, retrofitting becomes the only solution. However, this can often be a difficult and costly procedure; in addition some of the external mitigative features may not blend in with the aesthetics of the structure.

METHODS OF PREDICTING SNOW INFILTRATION

While some general guidelines for design will be given in this paper, these will not always resolve the problems associated with snow infiltration. Evaluation of the microclimate in combination with specifics of each mechanical system greatly increases the capability to determine and reduce the potential for problems.

To conduct an efficient and effective analysis, we have developed a system which involves a step by step method using computer analysis and physical modelling and considers both the mechanical design of the fresh air system and the microclimate. The procedure is outlined below and is also shown in the form of a flow chart in Figure 1.

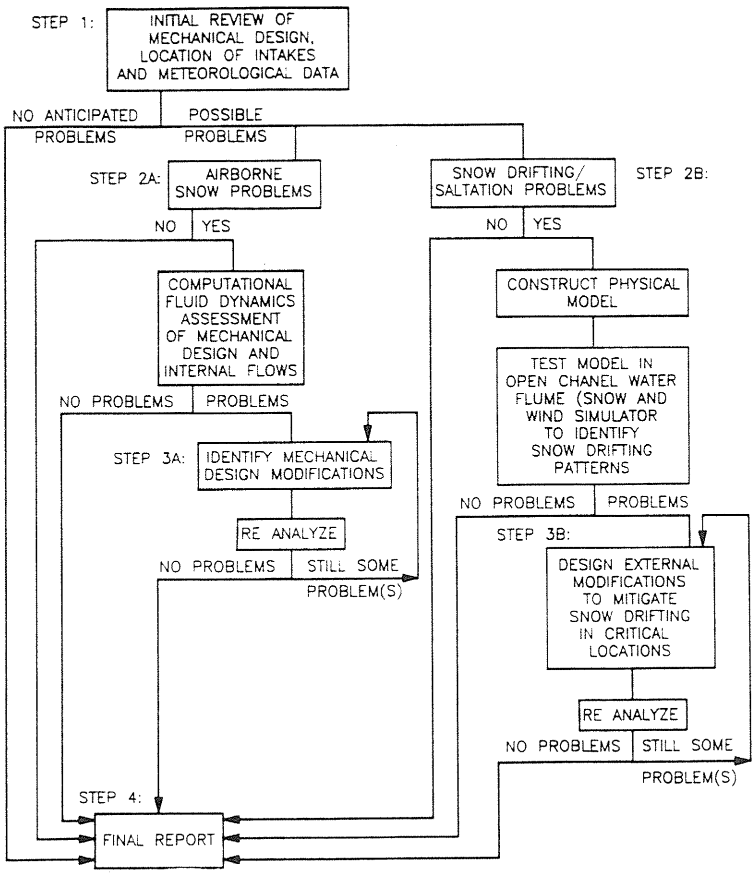

Figure 1: Method of Analysis for Snow Infiltration

Step 1: An initial review of the mechanical design is conducted along with a review of the location of the fresh air intakes, a review of the building shape and surrounding structure, and an evaluation of the meteorological data. This will determine the potential for snow infiltration problems from airborne (falling) snow and from drifting snow. If no problems are anticipated the assessment ends here, if problems are anticipated continue with Steps 2A and 2B.

Step 2A: If problematic snow infiltration resulting from airborne snow is anticipated, an evaluation of the internal flow characteristics of the intake system is conducted. The application of calculations and Computational Fluid Dynamics (CFD) is appropriate for this evaluation. If this assessment shows no concern due to airborne snow, this aspect of the study is complete.

If potential problems are shown, then appropriate design modifications are investigated as per Step 3A.

Step 2B: If problematic snow infiltration, resulting from drifting snow, is anticipated an evaluation of snow drifting problems and accumulations is conducted by physical model simulation in an open channel water flume. If the physical model tests identify drifts of concern, methods of mitigating these accumulations are evaluated as per Step 3B.

Step 3A: Modifications to the internal design are conducted and evaluated through calculations and CFD. This procedure may be iterative and will be conducted until the concerns are sufficiently addressed and the appropriate parties are in agreement with the design modifications.

Step 3B: External mitigative features are examined and evaluated on the physical model by conducting snow accumulation tests in the water flume. As in Step 3A, this process may be iterative and will be conducted until the concerns are sufficiently addressed and the appropriate parties are in agreement with the mitigative features.

Step 4: Final report.

TYPICAL PROBLEMS AND SOLUTIONS

Figure 2 illustrates a fresh air intake system subject to potential snow infiltration problems. The problems are a result of both the mechanical design and the microclimate. The potential problem areas are numbered on the figure and described below.

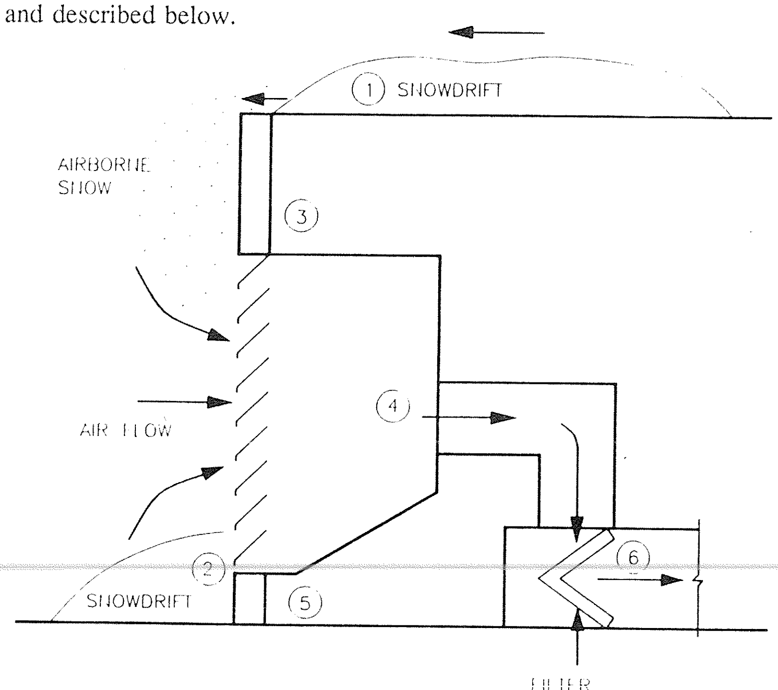

Figure 2: Fresh Air Intake with Potential Snow Infiltration Problems

Problems:

External

1) Snow from drifts on top of a mechanical penthouse will blow over the edge and increase the amount of snow drawn into the air intake system.

2) Snowdrifting in front of the louvres will increase the amount of snow drawn into the air intake system.

3) Locating the louvres close to roof level will increase the impact of roof level snowdrifting thus inducing the problem described in Point 2 above.

Internal

4) Locating the duct opening too low within the plenum will increase the amount of airborne snow drawn into the air intake system.

5) An inclined design feature at the base of the plenum will reduce the amount of snow storage capacity. Snow accumulation in the air stream flow will induce more snow entrainment in the air intake system.

6) The amount of snow drawn into the system could clog the filters and cause the ducting to collapse.

Figure 3 illustrates proposed design modifications and external mitigative features to reduce the impact of snow infiltration on the system shown in Figure 2. The solutions are numbered on the figure and described below.

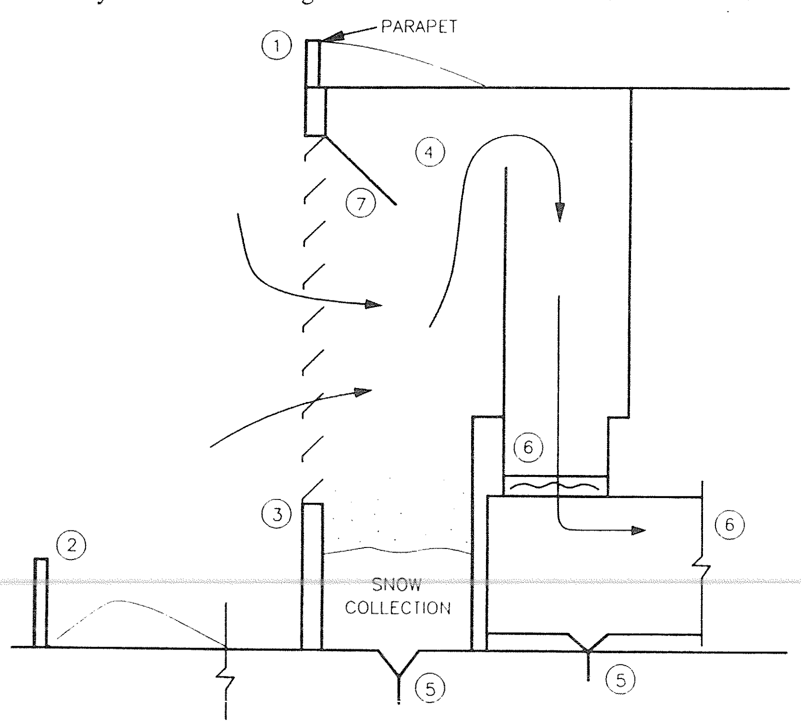

Figure 3: Modified Fresh Air Intake Reduces the Impact of Snow Infiltration

Solutions:

External

1) The addition of a parapet to the roof of the housing will reduce the amount of snow drifting over the edge of the penthouse roof thus reducing the amount of snow drawn into the air intake system.

2) Provided proper distance is available, the placement of roof level snow "fallout" devices such as fencing, screening, walls, vegetation, etc., upwind of the louvres, will reduce the snow accumulation in front of the louvres.

3) Locating the louvre system high up on the mechanical penthouse wall will reduce the impact of snowdrifting on the air intake system.

Internal

4) Locating the air intake duct high within the plenum will reduce the amount of airborne snow particles drawn into the system.

5) A sufficiently large snow and rain storage area within the plenum, complete with a drainage system, will help remove meltwater and rain. Heating the snow storage area at the base of the plenum, along with heating the drainage system will reduce the amount of snow accumulation and the impact of clogged drains due to snow and ice.

6) The filters should be designed to open, if clogged, in order to prevent serious damage to the air intake system, i.e. collapsed ducts. Alternatively the filters can be placed downstream of widely spaced tempering coils designed to melt the snow and temper the fresh air.

7) A deflector will reduce the amount of snow particles entering the air intake system.

CASE STUDIES

Two case studies are described below. These studies are given to identify the practical application of a snow infiltration evaluation.

Case 1

Background

In this particular study, an evaluation was conducted at the design stage allowing for flexibility in the application of modifications. The study was conducted for a roof level fresh air intake situated on the sidewall of a mechanical penthouse.

Problem

It was determined in the initial review that the internal mechanical design was sufficient to handle a "normal" amount of snow infiltration. However, given the location and orientation of the louvre and the meteorological characteristics, this louvre would be subjected to a great deal of snow. The study focused on mitigating the external features in order to reduce the amount of drifting/blowing snow impacting the louvre.

Solutions

Through physical scale model tests in the water flume, various devices upwind of the louvre were examined along with various positions of the louvre above roof level.

The final results identified that a simple adjustment of the height of the louvre on the wall of the penthouse would sufficiently reduce the impact of snow infiltration on the system. This modification was easily carried out at virtually no extra cost to the developer as the study was conducted at the design stage. Had the louvre been installed at the location originally intended, the developer would have been exposed to the cost of retrofitting along with repairs associated with damage due to snow infiltration.

<u>Case 2</u>

Background

This case study pertains to a facility that did not have a snow infiltration study conducted prior to construction. During the first winter, the main fresh air intake was subjected to extreme snow infiltration problems. The design includes a large air shaft with a sidewall louvre.

Problem

In this particular situation, drifting snow was not a problem. The design of the intake shaft and the orientation of the louvre created the problem.

The duct opening joining the internal system to the air shaft was located at the base of the air shaft. Snow entering the air shaft through the louvre, settled at the base of the shaft and was then drawn into the duct opening. The air handling devices (i.e. filters, screens, heating, etc.) are located approximately 20 to 30 meters away from the air shaft, thus snow drawn into the system can settle in this internal length of ducting. The orientation of the louvre is such that it faces the prevailing snow-bearing winds. As well, the building design intercepts and redirects other secondary snow-bearing winds causing them to pass in front of the air shaft louvre.

After one particular snow storm, occupants of the facility noticed a large amount of water seeping through the ceiling and walls. Upon inspection of the ducts it was revealed that several drifts of snow had accumulated in the 20m to 30m length of duct. The internal building heat was melting this snow thus creating the water damage.

Solutions

A primary solution would be to relocate the louvre on a different wall however this is a very costly retrofit. Fortunately the air shaft is of sufficient size that internal modifications are relatively easy to construct, they include:

1) relocate the duct opening in the plenum from the bottom of the shaft to the top
2) install deflectors to reduce the amount of snow exposed to the duct opening
3) seal the base of the air shaft and make use of the drainage system already available
4) install heat tracing elements to melt accumulated snow

CONCLUSIONS

Methods of predicting snow infiltration are relatively new. The general trend among mechanical designers has been to use engineering judgement and hope for the best. The methods discussed in this paper can be used to resolve snow infiltration problems. They also provide an understanding of the potential for snow infiltration under specific circumstances, based on mechanical design, architectural design and the microclimate.